A Study on Questionnaire for Self-Diagnosis Rheumatoid Arthritis

Eun Soo Choi, Seo Won Song, Yeun Su Kim, Ji Hyung Yoo, Chunhwa Ihm, Mi Kyoung Lim, Dong Hyuk Sheen, Min Soo Kang

Abstract: In recent years, population aging issues are emerging all over the world. The Korea society is expected to be a super-aged society. As the elderly society progresses, the theme of management of elderly patients is the quality of life. In the aged society, rheumatic diseases are more common than any other diseases, and rheumatic symptoms are the pain of the musculoskeletal system, which lowers the quality of life. So, if it is possible to diagnose rheumatoid arthritis in an easy way, prevention and deterioration of arthritis can be prevented, which can improve the quality of life of elderly patients as well as patients with all rheumatoid arthritis. Therefore, in this paper, we extracted 44 items related to rheumatoid arthritis physical symptoms from EMR DB and selected 10 questions through consultation by medical doctor. All of the questions are specified the weight according to importance to diagnose the rheumatoid arthritis, the questionnaire calculate the probability of being rheumatoid arthritis patient, through this weight. Proposed questionnaire will make possible self-diagnosis, early diagnosis, prevent undertreat, and the data collection from this questionnaire are very worthy found in the future research as well as medical research.

Index Terms: Diagnosis, Musculoskeletal disease, Rheumatoid arthritis, Self-diagnosis

I. INTRODUCTION

The growing number of elderly people around the world is raising interest in health care. The healthcare is the maintenance or improvement of health by through the prevention, diagnosis and treatment of mental disease as well as physical [1]. In the past, healthcare 2.0 was a treatment for disease but in the case of healthcare 3.0, it has been emphasized that the concept of health is not just about the absence of disease, but about the state of complete mental, physical and social well-being [2]. In the 1970s and 1980s,

From the 1970s to the 1980s, medical devices and equipment were mostly focused on identifying and diagnosing the patient's condition rather than devices for personal health care, and their size and weight were generally large and heavy. Since the 1990s, Medical devices for monitoring and identifying a patient's condition in the vicinity of a patient or in a patient's room have become widely used but are still unsuitable for use as a personal medical device. Importantly, medical services including medical devices began to shift from doctor centered to patient-centered. From the late 1990s to the early 2000s, patient-centered health services evolved more rapidly. As environmental factors such as growth of the elderly population and medical cost change rapidly, the concept of health changes. Recently, the health care system has changed from treatment-oriented to prevention and healthcare, it focused on providing personalized services to predict the possible diseases and prevent them in advance. In addition, treatment methods are converted from standard prescriptions that do not take individual characteristics into customized treatments considering genetic predispositions and constitution, and the diagnosis and treatment are improved in precision, and early diagnosis is becoming possible. The medical consumers are not simply seeking to live longer (life expectancy) but seek to "live longer (healthy lifetime)" and try to reduce the burden of medical expenses. Many of the current personal medical expenses are used to treat the disease after it develops, but it is predicted that it will also cost a lot of money to maintain the health of the patient [3].

Recently, research on e-health which use of information and communication technology (ICT) for health has been actively conducted. Artificial intelligence predicts human perception, reasoning, and machine learning by computers and systems, and it has been applied to real hospitals [4,22-26]. In December 2016, the Gil Hospital of Gachon University of Korea adopted medical artificial intelligence by applying Watson for Oncology. Through its natural language processing technology, Watson for Collage has learned more than 600,000 scientific evidence, more than 2 million documents in 42 medical journals, more than 60,000 clinical trials, and more than 1,500 lung cancer cases. Since 2012, he has been working with doctors at the Memorial Sloan Kettering Cancer Center in Cancer Center in New York City. [5]. Research on applying artificial intelligence to these medical fields is likely to continue. Although the social and economic environment of Korea has been improved much more than the past,

Eun Soo Choi, Seo Won Song, Dept. of Medical IT Marketing, Eulji University, Seongnam, Korea

Corresponding Author, Min Soo Kang*, Dept. of Medical IT Eulji University, Seongnam, Korea

Yeun Su Kim, Eulji University Hospital Integrated Computing Center, Daejeon, Korea

Ji Hyung Yoo, Internal Medicine, Cheongyanggun Health Medical Center, Cheongyanggun, Choongcheongnamdo, Korea.

Chunhwa Ihm, Dept. of Laboratory Medicine, Eulji University Hospital, Daejeon, Korea

Mi Kyoung Lim, Dong Hyuk Sheen, Dept. of Rheumatic Internal Medicine, Eulji University Hospital, Daejeon, Korea

the frequency of diseases including chronic diseases is increasing as the society becomes aging society. Disease has a very large impact on individual and family societies, ranging from minor effects on human life to disability or death. The increase in the elderly population leads to an increase in the number of elderly patients. As the elderly society progresses, the theme of management of elderly patients is the quality of life. This is the same as the goal of chronic disease management for the elderly, focusing on bone metabolic diseases, and it is necessary to manage the quality of life for the elderly [6].

Table 1: Prevalence and cure rate of chronic diseases of elderly of over 65 years old, Ministry of Health and Welfare

Disease	Total (%)		Male (%)		Female (%)	
	Prevalence	Cure	Prevalence	Cure	Prevalence	Cure
High blood pressure	56.7	98.6	51.9	98.1	60.2	98.9
(Rheumatoid) Arthritis	33.4	84.2	17.9	83.7	44.5	84.3
Diabetes	22.6	97.5	22.2	98.2	22.8	97.1
Backache	21.1	82.1	12.6	78.3	27.2	89.3
Hyperlipidemia	19.6	96.1	14.6	96.2	23.2	96.0
Osteoporosis	14.0	80.9	2.7	76.3	22.1	81.3
Cataract	8.7	69.3	6.8	70.8	10.0	68.6
Prostate enlargement	8.2	92.9	19.7	92.9	0.0	0.0
Stroke	6.9	95.6	8.0	93.6	6.0	97.5
Angina, Cardiac infraction	6.8	97.4	6.8	98.3	6.9	96.8

The table 1 represents the prevalence and cure rate of chronic diseases of elderly of over 65 years old. It was analyzed for respondents who were diagnosed as having a medical diagnosis for each chronic disease. Especially in the aged society, rheumatic diseases are more common than any other diseases, and rheumatic symptoms are the pain of the musculoskeletal system, which lowers the quality of life of patients. It affects not only simple disorders but also daily life likes Chronic pain, reduced mobility and complications may occur (depression, cardiovascular disease etc.). According to fig 1, the number of domestic arthritis patients is increasing. As the figure1, the number of patients with arthritis in 2006 was 4.3 million which is increased by 40% in 2015 to 6.1million.
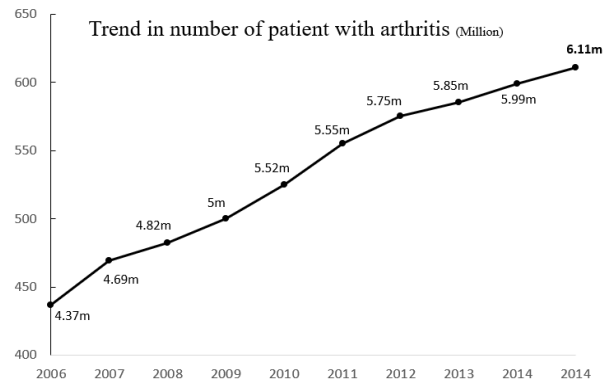

Fig.1: Trend in number of patients with arthritis, National health insurance service

This implies that arthritis is not a restricted disease for the elderly. Therefore, if diagnosis of rheumatoid arthritis can be done in an easy way, it makes possible to diagnose disease early, prevent disease and improve not only the quality of life of elderly but also the younger generation's [7].

II. RELATED RESEARCH

A. Diagnosis rheumatoid arthritis

In studies on rheumatoid arthritis, some features have been focused on which related the rheumatoid arthritis, such as pain on joint or near joints, the duration of a symptoms, related physical symptoms. There were many approaches based on physical symptoms associated with arthritis. In recent years, ICT technology has been introduced. Rheumatoid arthritis is a chronic inflammatory disease, so an early diagnosis is important [8]. GALS (Gait, Arms, Legs, Spine) methods introduced to more easily and quickly inspect and record musculoskeletal abnormalities. The GALS method can be used as a useful method to record the abnormalities and dysfunctions of the musculoskeletal system by expressing the complicated physical examination easily and simply [9]. It designed for use in primary care and has been used for educational purposes of musculoskeletal disease physical examination methods in Europe, including the UK [10]. The history of classification criteria for rheumatoid arthritis begins with the classification criteria published by the American Rheumatism Association in 1958. And the revised classification standard was published in 1987 by the ACR (American College Rheumatology). 1978 ACR criteria is useful as a method to differentiate arthritis from other types of rheumatoid arthritis or diagnose rheumatoid arthritis which has already progressed much, but it is difficult to diagnose rheumatoid arthritis early. And ACR and EULAR (European League against Rheumatism) introduced a new classification standard in 2010. It considers the standards such as rheumatic factor and duration of symptoms and diagnose rheumatoid arthritis if the result is more than 6 (the total score is 10 points) [11].

Although the 1987 ACR classification of rheumatoid arthritis and the 2010 ACR / EULAR have been studied, the validity and limitations of the two criteria have not been done [8]. In addition, studies on the diagnosis of arthritis have been conducted. Jin Suk Kim proposed a diagnostic algorithm based on history and clinical findings of musculoskeletal pain patients. He mentioned differential diagnosis of arthritis can be made by more than 80% of the patients only by listening to the medical history and physical examination, and additional information through the test can help to make an accurate diagnosis. Therefore, the clinical features of each disease and the findings of physical examinations are important for access to musculoskeletal patients [12].
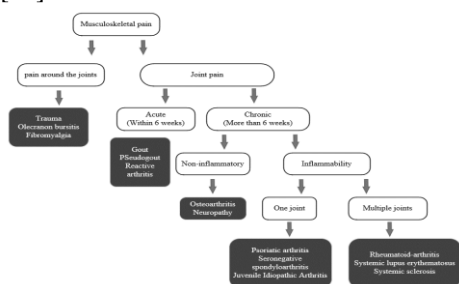

Fig.2: Diagnostic algorithm for history and medical examination of musculoskeletal pain patients

Won-Jun Choi compared the validity of two questionnaires (NIOSH and Nordic-style) for diagnose musculoskeletal disease. The NIOSH Style questionnaire is the musculoskeletal disorders symptoms questionnaire that used in musculoskeletal burden jobs hazard investigation, designed to answer questions about the symptoms associated with musculoskeletal disorders, duration, frequency and intensity of symptoms by each part of body. In the case of Nordic-style questionnaire developed for the purpose to make easier to compare musculoskeletal symptoms with each other at the aspect of industrial health. It consists of two parts: a general questionnaire and a questionnaire about each part of the body. Frequency and intensity are not included. The author noted that questionnaire-based diagnosis is easier for the investigator to respond and will be useful in identifying the presence and flow of musculoskeletal disorders [13].

B. Development of medical informatics and EMR

Medical Informatics is defined as a system that efficiently organizes and manages various kinds of information needed for patient medical treatment, medical education, medical research and medical management. Therefore, medical informatics is a complex field covering cognitive science, educational psychology, decision-making theory, information science and computer science. The 1960s was the golden age of development of medical informatics, and many research projects using computers for medical research were carried out. The achievements of this period are still being used or imitated, and in the data processing sector, practical programs were completed during this period and research on information processing began. In the 1970s, development of computer hardware, networks and computer languages was further accelerated, and applications in the medical information field were also actively carried out. Various hospital work began to be computerized and universalized. In other words, computerized programs such as nursing, medicine, radiological image processing, nuclear medicine information, nutrition, receipt, patient reception, reservation, hospitalization, transfer record and medical record were developed. In the 1990s, medical informatics, combining new technology and medicine, gradually became reliable. The rapid spread of the Internet has made great progress in medical information systems. Hospital information processing technologies are integrated, and the convenience of users has improved greatly. The addition of the Picture Archiving Communication System (PACS) to this technology development has enabled the transmission of not only radiological images but also pathological images. In addition, remote consultation between the medical institutions and telemedicine between the patient and the physician is also possible. Informatization for simple patient management has been successfully established and used in most advanced countries including Korea. In recent years, medical informatics techniques have been introduced in not only the informatization of medical fields, but also in medical research and medical education [14]. With the development of healthcare information and communication technology, computerized system is widely used for patient care. In medical institutions, the core of this computerized system is Electronic Medical Records (EMR) systems. The EMR system shows the difference in terms from the Electronic Health Records (EHR) system, EMR refers to the electronic version of the patient's clinical record, which is an episode, in an electronic form, EHR refers to the inclusion of all records received not only from EMR but also from other institutions or patients themselves. In Europe, the term Electronic Patient Records (EPR) is also commonly used, all of these are interchangeable because they are a record of the computerized system associated with patient care. Patient diagnosis, history, and examination results of patients stored in such a system can be conveniently used by medical personnel within the legal framework for the patient care. Compared with paper charts in the past, it is easy to store, and convenient to store various information. The reason that the medical institution computerize patient medical care is not only convenience, but also the information necessary for making various decision making at the time of medical treatment can be supported and connection with the internet is also possible. There are a lot of positive research results rather than negative aspects, and the use of EMR system is encouraged both domestically and internationally. The reason the government is interested is that, as mentioned above, it can be expected indirectly to reduce the medical expense by improving the quality of medical services, reducing administrative costs associated with computerization, and preventing duplicate examination for other information exchanges. If patient information stored in a medical institution is constructed in standardized form, and information can be

exchanged and shared regardless of the form of an electronic medical record system, and viewed as necessary, probably the ideal form of delivery system will be established. And these clinical data, which are generated by the medical institutions are combined with genetic information, lifestyle information, and so forth, applies the core technologies of the fourth Industrial revolution, based on this, it is becoming the basis of precision medical care to find the cause of all diseases and ultimately to provide personalized medical service to individuals.

Recently, as the service competition among the medical institutions becomes more serious, the passive management method, which is waiting for the patients to come, is being transformed into an active management method for attracting the patients to the hospital. As digital hospital aims at 4Less (Chartless, filmless, slip-less, paperless) which uses various information technology to eliminate chart, film, slip and paper in hospital, electronic medical record becomes the basis of digital hospital. The electronic medical records started from the office automation of the hospital work to simplify. From the automation of simple repetitive tasks and administrative tasks, it gradually evolved to store and manage patient's medical records in computer. In the second stage, the paper chart is scanned and stored as an image. As a result, vast amounts of medical records are not only easier to store and manage but are also easier to find and use. This type of medical care information is not a method of scanning and storing the records on a page but progressing to three stages of subdividing all items and storing and managing each item in various forms such as text and images. In this way, medical institutions can analyze electronic medical records in various forms and use them for more accurate diagnosis. In addition, the electronic medical record has developed to the next stage called EHR, which allows medical information to be exchanged between medical institutions over the range of the inside of the hospital and to be used jointly. Ultimately, it will evolve to Personal Health Record (PHR) phase, where all data, including personal health records, such as smoking, exercise, and dietary habits, are managed as well as individual medical records that are stored and managed at various medical institutions [15].

Through the introduction of electronic medical records, it is expected to reduce patient waiting time, minimizing the manual operation of medical institutions, reducing document management costs, increasing the convenience of information storage, facilitating access to medical records for patient records, and various utilization of information. One of the biggest advantages is that it stores vast clinical cases of patients and enables medical staff to get accurate and quick access. This enables multidimensional analysis, the medical institution maximizes the safety and efficiency of medical services by utilizing extensive medical experience and accumulated knowledge in medical research and it is also used as the management data. The fundamental application of the electronic medical records system is to study data accumulated at the medical site to find evidence and apply the evidence to the patient's medical treatment process again.

Through this series of processes, experience and data are accumulated, and through a virtuous circle process ultimately digital healthcare is realized. However, it's not easy to analyze electronic records data. The data stored is very complicated, the kinds are diverse and there are many missing data. And there are now more ways in which various data are measured. More and more healthcare apps, wearable devices, internet-of-things sensors, and portable medical devices are on the market, all of which produce data in some way. With the spread of electronic medical records, clinical research methods are changing. Aside from the way in which the patient's medical records recorded on paper are found, stacked, and reviewed, it is possible to sit in front of a computer to search and review the medical records. Observational studies of millions of patients using EMR have been reported frequently, as researchers can access the EMR system directly, select the subjects, and verify hypotheses in a short time [16].

C. Application of ICT in healthcare

Recently, ICT technology has been applied to medical field to find out disease-related factors, and predict disease, etc. With the development of Internet technology and the spread of mobile devices, the amount of information and communication data is increasing rapidly. Data utilization in traditional industries has expanded, and how to utilize big data gradually has become an industry-wide concern. The data itself is starting to be viewed as an economic asset. Big Data enables higher effects and more variety of services. It is noted that the use of big data will be most valuable in health care. This is because medical information collected by various devices can be stored and analyzed and processed in various forms so that medical staff can use it. For example, the use case of application big-data to medical fields, the National Institute of Health (NIH) has established a disease treatment system through gene data sharing that can share and analyze gene data to manage and predict disease that is a major control target in order to study various diseases. Currently, 1,700 gene information is stored in the Amazon. The National Laboratory of Medicine, under the National Institute of Health (NIH), is promoting health reform through the Pillbox project, which provides information about a variety of drugs required by users. Pillbox is a drug-searching site run by NLM, it can help prevent misuse of medicines by providing information about the various drugs that users require and providing accurate information about them. The number of complaints that inquire about the function and the period of validity of pills received at the National Institutes of Health is over 1 million with an average of $50 per unit cost, it estimates there will be a $50 million annual cost savings. Big data collected through Pillbox are used to obtain statistical data on the distribution of major diseases such as acquired immunodeficiency syndrome (HIV) and the yearly increase.

There are cases where artificial intelligence is applied. IBM and U.S. health insurance company WellPoint have developed and provides applications that doctors and other health care staff can use to diagnose and treat patients. It analyses the health insurance data and patient information about 34.2 million registered in the company and informs medical treatment method based on this analysis. Watson analyses past data, including clinical trials and best practices, to provide the most appropriate treatment for the patient and the latest information in a scientific way. It stores all the information about the patient's symptoms, interview results, diagnosis, etc., and suggests optimal diagnosis and patient's treatment guidelines considering all cases through the server. According to data published by the American Society of Clinical Oncology (ASCO), Watson's overall treatment accuracy is reported to be 82.6% [17]. Google is providing a flu prediction service through analysis of search terms related to the cold. The Google Flu Prediction Service provides accurate information in real time by processing meaningful data back to users through keyword analysis of various users [18]. Machine learning has become a core technology for data mining and modeling for medical research as well as for IT. Already, machine learning has been used around the world, including Google's Alpha-Go, TensorFlow, Microsoft Azure and IBM's Watson. Ji Hyung Yoo, Mi Kyoung Lim, Chun Hwa Ihm, Eun Soo Choi, Min Soo Kang, they applied Machine learning to predict rheumatoid arthritis. They used clustering method of machine learning, to predict rheumatic disease patients in advance. [19] It can help not only to determine whether a disease is present but also predict the patient disease prognosis.

In this study, we extracted physical symptoms related to rheumatoid arthritis from EMR DB. After the consultation by medical doctor the weight is given according to importance and selected questions. Patients fill out the questionnaire, they could know the probability of being a rheumatism patient. Questionnaire has been discussed in section 3, finally conclusions are stated in section 4.

III. A STUDY ON QUESTIONNAIRE FOR SELF-DIAGNOSIS

The population is aging all over the world. Health care in the past is a trend that is focused on therapy, but more recently, on management. In other words, there is a growing interest in living longer in good health. So, the importance of living a pleasurable life rather than merely maintaining life is growing. In the aged society, rheumatic diseases are common than other diseases, and rheumatic symptoms are the pain of the musculoskeletal system, which lowers the quality of life. Rheumatoid arthritis is associated with pain in several joints and symptoms such as stiffness gradually appear over several weeks. More than 2/3 of patients experience some symptoms such as fatigue, anorexia and joint symptoms. Rheumatoid arthritis is a chronic inflammatory disease, but recent studies have shown that early treatment can slow the progression of the disease. In addition, early active treatment can reduce joint destruction or dysfunction [20]. Therefore, if diagnosis

of rheumatoid arthritis can be done in an easy way, it makes possible to diagnose disease early. Furthermore, it can improve not only the quality of life of elderly but also the younger generation.

As the diagnostic algorithm in fig 2, Physical examination should be performed after the interview for physical symptoms. Especially, patients complaining of musculoskeletal symptoms first should determine whether the joint symptoms are joint area problems or around joints. After that, if the joint is a problem, a diagnostic approach should be made by identifying acute or chronic, inflammatory, invaded and invaded joints [21]. If the medical examination by interview replace in an easy way such as questionnaire, it makes possible to use at any time, even if the patients are not in a hospital. In addition, it will be helpful for early diagnosis of musculoskeletal disorders as well as rheumatoid arthritis.

We have developed a questionnaire that can be used to diagnose rheumatoid diseases by extracting and screening symptoms related rheumatoid arthritis from DB. In order to make self-diagnosis questionnaire, we extracted over 40 symptoms from EMR related to rheumatoid arthritis, gave the weight according to the importance through consultation by medical doctor and selected questions. The patients can check their status through proposed questionnaires so they can detect early and prevent disease. And the doctor can obtain useful diagnostic information during the time of medical examination of suspected rheumatic disease patients
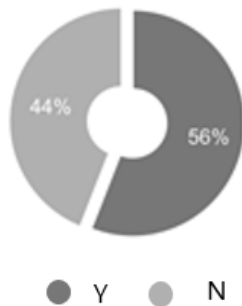

Fig.3: Example of questionnaire

Fig.3 shows a scene of the questionnaires generated by the weights. The question of figure3 confirms the presence of arthritis. In addition, it consists of questions for identify the pain parts, duration, inflammatory arthritis, and rheumatoid arthritis. After responding to questions, the questionnaire calculates the probability of having rheumatoid arthritis. The probability is the sum of the weights of the question answered by yes is divided by the sum of all the weights of questionnaire.

Fig.4: Example of questionnaire result page

Patients may be able to self-diagnose rheumatoid arthritis by the probability of being rheumatoid arthritis patient. If the probability is high, the patient will want to go to the hospital, if he is a rheumatoid patient, early diagnosis and treatment would be possible. Even if the probability is low, the respondent can identify the symptoms of the disease and can be prevented.

IV. CONCLUSION

Currently, Korea is an aged society, and it is expected to become a super-aged society. As the elderly society progresses, the important thing of management of elderly patients is the quality of life. Especially in the aged society, rheumatic diseases commonly occur, it affects not only simple disorders but also daily life and develop complications may occur (depression, cardiovascular disease etc.). These rheumatoid arthritis symptoms lower the quality life. So, we proposed a Diagnosis of Rheumatoid Arthritis Based on Artificial Intelligence. In this paper, we made 44 items related to rheumatoid arthritis physical symptoms like pain on joint and select 10 questions through consultation by medical doctor. All the question is specified the weight according to importance to diagnose the rheumatoid arthritis, the questionnaire calculate the probability through this weight. First, the patient will fill out the questionnaire either at waiting time in hospital or outside. The questionnaire is prepared by weight according to the importance which used to calculate the probability of being a rheumatism patient. The questionnaires answer by the patient and it provide the quantified results of the rheumatoid arthritis diagnosis. After that, patient can confirm his status with the probability of being rheumatoid arthritis patient and decide to visit hospital or not. If the patient visit hospital, the doctor does a physical examination and inform the patient of the final diagnosis result.

Proposed questionnaire makes possible to self-diagnosis, early detect and prevent undertreat the disease, it would improve the quality of life. Weights of rheumatoid arthritis questionnaire will be able to detect patients with rheumatoid arthritis with high efficiency in less time and to identify trends in patients and apply them to therapies. The weight is given through doctor consultation and after the actual application, questions and weight adjust may be needed by analyzing the responses and trends of the patients. When a doctor is treating a patient suspected rheumatoid arthritis, the questionnaire can be referred. In the case of patient, he can early detect by self-diagnosis and it is expected to actively participate treatment since he can check his status. Furthermore, if the results from the questionnaire are accumulated, a more accurate prediction can be made. And if it is applied with ICT technologies such as machine learning, it can develop a management system that covers diagnostic approach and patient follow-up care.

ACKNOWLEDGMENT

REFERENCES

1. Healthcare, Wikipedia: The free encyclopedia, Available: https://en.wikipedia.org/wiki/Health_care
2. Eun Jin Choi, Hee Ran Chae, Jeong Yeon Park, Jackie Green, Katrin Engelhardt, Health Promotion Policy Development in accordance with the Paradigm Shift from Curative measures to Preventive measures, 2011
3. http://magazine.hankyung.com/apps/news?popup=0&nid=01&c1=1001 &nkey=2013011000893000201&mode=sub_view
4. Min Soo Kang, Eun Soo Choi, Getting Started with Machine Learning with Microsoft Azure ML, Hanti Media, 2018
5. Da Eun Lee, Artificial intelligence is this medical innovation?: Focusing on the introduction of Watson in Gil Hospital, Sci-ence & Technology Policy, No.227, 2017
6. Min Soo Kang, "Development of ROM Measurement Device capable of IoT-based Real-time Monitoring for Rehabilitation Patients", The Journal of the Institute of Internet, Broadcasting and Communication (JIIBC), Vol. 18, No. 4, pp. 111-116, 2018
7. http://www.mostonline.co.kr/news/articleView.html?idxno=95876
8. Su-Jin Moon, Chang Hoon Lee, Yun Sung Kim, Yun Jung Park, Kwi Young Kang, Seung Ki Kwok, Hae Rim Kim, et al, " Usefulness and Limitation of 2010 ACR/EULAR Classification Criteria in Korean Patients with Early RA." Journal of Rheumatic Diseases 19.6, 2012
9. Doherty M, Dacre J, Dieppe P, Snaith M. The 'GALS', locomotor screen. Ann Rheum Dis 1992; 51:1165-1169.
10. Sung Won Lee, Physical Examination of Arthritis, The Korean Journal of Internal Medicine, 2012, 83.2: 162-173.
11. Jung-Soo Song, "New classification criteria for rheumatoid arthritis", Korean Journal of Medicine 87.4: 383-388, 2014
12. Jin Seok Kim. "Essentials of Primary care: rheumatism.", The Korean Journal of Medicine 2017.2 (2017): 368-372.
13. Won-Jun Choi, Nak-Jung Sung, Young-Joong Kang and Sang-Hwan Han, "Validity of NIOSH- and Nordic-style Question-naires in the Screening and Surveillance of Neck and Upper Ex-tremity Work-related Musculoskeletal Disorders". Annals of Occupational and Environmental Medicine, Vol. 20, No. 3, pp. 205~214, Sep 2008
14. The Korean Society of Medical Informatics, Medical Informatics(2nd), Hyunmoon, 2009, pp21-28.
15. Jin Ok Jeon, Electronic medical records of Korea introduction status and development tasks, HIRA, vol.12, no.3, 2018

16. https://m.blog.naver.com/PostView.nhn?blogId=mibyeong&logNo=2208 91096463&proxyReferer=https%3A%2F%2Fwww.google.com%2F
17. https://jmagazine.joins.com/economist/view/310466
18. NIA (National Information Society Agency), Big Data Global 10 Best Practices, Available: http://contents.kocw.or.kr/KOCW/document/2014/korea/kimseongtae/17. pdf
19. Ji Hyung Yoo, Mi Kyoung Lim, Chun Hwa Ihm, Eun Soo Choi, Min Soo Kang, "A Study on Prediction of Rheumatoid Arthritis Using Machine Learning." International Journal of Applied Engineering Research, 12(20), 9858-9862, 2017
20. Raza Karim, "The Michael Manson prize: Early rheumatoid arthritis the window narrows.", Rheumatology 49.3, 406-410, 2009
21. Eun Bong Lee, "Special Review : Clinical manifestations and differential diagnosis of arthritis", Korean Journal of Medicine, Vol. 82, No. 2, pp-157-161, 2012

.